CONCISE STATEMENT OF RELEVANCE

for

JP 07-066138-A1

This invention is a plasma device for forming a thin film on a workpiece. A reactant gas is provided through an installation hole of an electrode in a manner to form a thin film of uniform thickness on the workpiece.

PATENT ABSTRACTS OF JAPAN

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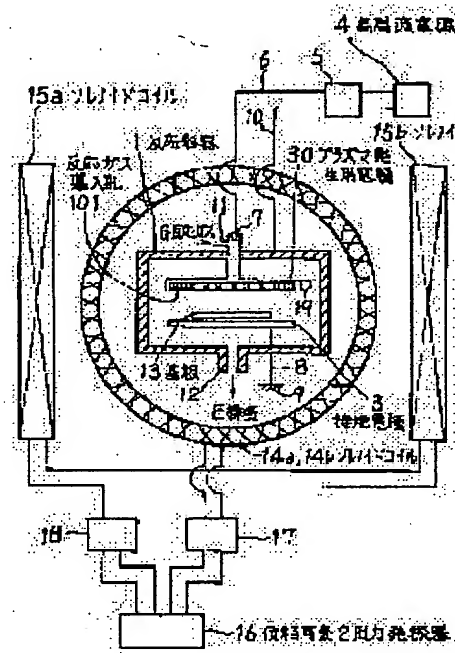
(54) PLASMA CVD SYSTEM

(57)Abstract:

PURPOSE: To allow deposition of a uniform thin film on a substrate from the central part to the peripheral part thereof.

CONSTITUTION: Reaction gas is introduced between an electrode 30 for generating plasma and a ground electrode 3 disposed in a reaction chamber 1. Power is fed from a high frequency power supply 4 to the electrodes 3, 30 in order to generate glow discharge plasma therebetween. On the other hand, solenoid coils 14a, 14b, 15a, 15b, disposed perpendicularly each other, are fed with field generating power from respective AC power supplies 16 and a force for fluctuating the plasma is generated by a rotating field in a plane extending in parallel with a substrate 13. Since the plasma generating electrode 30 is provided with plasma introduction holes 101 having diameters increasing gradually toward the periphery, the reaction gas is distributed uniformly from the central part to the peripheral part thus forming a thin film uniformly on the substrate in conjunction with the force of rotating field.



LEGAL STATUS

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CLAIMS

[Claim(s)]
[Claim 1] A reaction container, a means to introduce and discharge reactant gas in this reaction container, and the electrode for plasma generating that has the earth electrode held in said reaction container, and the introductory hole of said reactant gas, Two pairs of solenoid coils installed on both sides of the reaction container so that it might become in the direction in which it intersects perpendicularly with the power source which supplies the power for glow discharge to this electrode for plasma generating, and the electric field between said two electrodes, and an axis intersects perpendicularly mutually, In the plasma-CVD equipment which forms an amorphous thin film on the substrate supported so that it might come to provide the AC power supply which supplies the power for field generating to these solenoid coils and might intersect perpendicularly with the electric field between said two electrodes The reactant gas installation hole of said electrode for plasma generating is plasma-CVD equipment characterized by a periphery forming so that the discharge quantity of said reactant gas may increase.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the plasma-CVD equipment suitable for manufacture of the large area thin film used for manufacture of various electron devices, such as an amorphous-silicon solar cell, a thin film transistor, a photosensor, and a semi-conductor protective coat.
[0002]
[Description of the Prior Art] In order to manufacture a large area amorphous silicon thin film, the configuration of the plasma-CVD equipment used conventionally is explained with reference to drawing 9 thru/or drawing 11 . In the reaction container 1, the electrode 2 for plasma generating and earth electrode 3 for generating the glow discharge plasma are arranged in parallel mutually. The power of the frequency of 13.56MHZ(s) is supplied to an electrode 2 through the impedance-matching circuit 5, the 1st high frequency cable 6, and the power installation terminal 7 from RF generator 4. The earth electrode 3 is connected to the ground 9 through the reaction container 1 and the 2nd high frequency cable 8. Moreover, the earth side terminal of the above-mentioned impedance-matching circuit 5 is connected to the reaction container 1 by the 3rd high frequency cable 10. In the reaction container 1, it lets the reactant gas installation tubing 11 pass from the bomb which is not illustrated and a flowmeter, for example, a mono silane G is introduced into the gap of the ground shielding 19 and the electrode 2 for plasma generating. The reactant gas between the ground shielding 19 and the electrode 2 for plasma generating passes along many reactant gas installation holes 20 of the electrode 2 for plasma generating, and is supplied between an earth electrode 3 and the electrode 2 for plasma generating. The reactant gas in the reaction container 1 is exhausted as Sign E shows with the pump which is not illustrated through an exhaust pipe 12.
[0003] The diameter of the reactant gas installation hole 20 of the electrode 2 for plasma generating and the gap of the ground shielding 19 and the electrode 2 for plasma generating are set up shorter than an electronic mean free path, in order to control that the plasma occurs in the gap. Moreover, all spacing of the reactant gas installation hole 20 with which the electrode 2 for plasma generating adjoins as shown in the top view of drawing 10 and the side elevation of drawing 11 is equal, and is arranged in the shape of a forward hexagon.
[0004] The substrate 13 used as a product is installed so that it may intersect perpendicularly with the electric field generated with the electrode 2 for plasma generating, and an earth electrode 3 in parallel with the electrode 2 for plasma generating, and an earth electrode 3.
[0005] Around the reaction container 1, the solenoid coils 14a, 14b, 15a, and 15b of finite length with the 1st - the 4th thickness are arranged. In a pair, as shown in nothing and drawing 6 , nothing and the 3rd and 4th solenoid coils 15a and 15b are also arranged [pair] for the 1st and 2nd solenoid coils 14a and 14b at parallel, respectively so that each axis may agree in the direction, i.e., X shaft orientations, and Y shaft orientations which intersect perpendicularly mutually. The power of a sinusoidal form is supplied to the 1st and 2nd solenoid coils 14a and 14b through the 1st power amplifier 17 from one output terminal of the phase adjustable 2 output oscillator 16. The power of a sinusoidal form is similarly supplied to the 3rd and 4th solenoid coils 15a and 15b through the 2nd power amplifier 18 from the output terminal of another side of the phase adjustable 2 output oscillator 16. In the above-mentioned phase adjustable 2 output oscillator 16, the field which the 3rd and 4th solenoid coils 15a and 15b generate is field distribution of strength respectively almost uniform in the direction of an axis by setting it as arbitration and being able to output in each relative topology about two sinusoidal signals at the 1st and 2nd solenoid coil 14a by these signals, and 14b list.
[0006] Using the above-mentioned equipment, as it is the following, a thin film is manufactured. A vacuum pump (illustration abbreviation) is driven and the inside of the reaction container 1 is exhausted. If let the reactant gas installation tubing 11 pass, for example, mixed-gas G of a mono silane and hydrogen is supplied, the pressure in the reaction container 1 is maintained at 0.05 - 0.5Torr and the power for glow discharge is impressed to the electrode 2 for plasma generating from RF generator 4, the glow discharge plasma will occur between two electrodes 2 and 3.
[0007] On the other hand, the sinusoidal power of the frequency which shifted two outputs from the phase adjustable 2 output oscillator 16 in the 1st and 2nd solenoid coil 14a and 14b list, and shifted 90 degrees of phases to the 3rd and 4th solenoid coils 15a and 15b is impressed, respectively. Field B1 according to the 1st and 2nd solenoid coils 14a and 14b at this time Field B-2 by the 3rd and 4th solenoid coils 15a and 15b The synthetic field B occurs. This synthetic field B is impressed to the above-mentioned glow discharge plasma, rotating with a fixed angular velocity in the direction which intersects perpendicularly to the electric field between the electrode 2 for plasma generating, and an earth electrode 3. As a result, the glow discharge plasma receives the force (E-B drift) rotated with a fixed angular velocity. Consequently, the glow discharge plasma between the electrode 2 for plasma generating and an earth electrode 3 is swung in all the directions in the inside of a field parallel to a substrate 13. In addition, the strength of the

synthetic field B is good at about 20-100 gauss. The reactant gas supplied from the reactant gas installation tubing 11 is decomposed by the glow discharge plasma produced between the electrode 2 for plasma generating, and an earth electrode 3.

[0008] Charged particles, such as a hydrogen ion, cause the so-called E-B drift motion by Coulomb force F1 =qE by the electric field E between the electrode 2 for plasma generating, and an earth electrode 3, and Lorentz force F2 =q (V-B) (it is here and V is the rate of a charged particle). A charged particle is driven in the direction which intersects perpendicularly with the electrode 2 for plasma generating, and an earth electrode 3 where initial velocity is able to be given by the E-B drift. Therefore, charged particles, such as a hydrogen ion, have hitting [little] a substrate 13 directly.

[0009] The radical Si which is neutrality electrically is not influenced of Field B, but swerves from the orbit of the above-mentioned charged-particle group, results in a substrate 13, and forms an amorphous thin film in the substrate front face. Radical Si becomes possible [forming an amorphous thin film in substrate 13 front face at homogeneity] by rotating the inside of a field parallel to the substrate 13 between the electrode 2 for plasma generating, and an earth electrode 3 for the synthetic field B generated from the 1st - the 4th solenoid coil 14a, 14b, 15a, and 15b in order to collide with the charged particle which flies the Rama orbit. In addition, since area of a substrate 13 is satisfactory even if it enlarges it, as long as it approves in the reaction container 1, it becomes possible [forming a uniform amorphous thin film in the front face of the large area substrate 13].

[0010]

[Problem(s) to be Solved by the Invention] With above conventional equipment, a large area and homogeneity membrane formation can be easily performed by rotating the field generated in the direction which intersects perpendicularly with the electric field which reactant gas is introduced [electric field] into homogeneity inter-electrode from the reactant gas installation hole 20 of the electrode 2 for plasma generating, and generate the glow discharge plasma in a substrate 13 and a flat surface field. However, there are the following problems.

[0011] (1) Although reactant gas is introduced into inter-electrode from the reactant gas installation hole 20 of the electrode 2 for plasma generating, distribution of the reactant gas of an electrode periphery is uneven as compared with distribution of the reactant gas of an electrode center section, and the reactant gas consistency of an electrode periphery is lower than the reactant gas consistency of an electrode center section. For this reason, even if it rotates the field of the direction which intersects perpendicularly to the electric field which generate the glow discharge plasma in a field parallel to a substrate 13, in case the amorphous silicon thin film of a large area is manufactured, the thickness of the amorphous silicon thin film of a substrate periphery becomes thin as compared with the thickness of the amorphous silicon thin film of a substrate center section. Therefore, it was very difficult to maintain thickness distribution of a large area amorphous silicon thin film to **10% or less, and to maintain [second] a membrane formation rate in 2A /or more.

[0012] (2) When manufacturing the amorphous silicon thin film of a large area from the above (1), since thickness becomes thin, a substrate periphery cannot be used for an amorphous-silicon solar cell, a thin film transistor, etc. For this reason, the large substrate beyond the need and a reaction container must be used, and it has become one of the factors of cost quantities, such as an amorphous-silicon solar cell and a thin film transistor.

[0013]

[Means for Solving the Problem] They are approaches, such as enlarging the diameter of a hole as this invention becomes a periphery from the center section of the electrode about the reactant gas installation hole prepared in the electrode for plasma generating of plasma-CVD equipment, in order to solve the above-mentioned technical problem. As for the thin film which is what the periphery was made to form so that the discharge quantity of reactant gas may increase, and abolished from the former the reactant gas distribution by the center section and periphery which were a problem, and the heterogeneity of a consistency, consequently is formed by the substrate front face, uniform thickness distribution is acquired in the whole substrate.

[0014] Namely, a means for this invention to introduce reactant gas at a reaction container and this reaction container, and to discharge, The electrode for plasma generating which has the earth electrode held in said reaction container, and the introductory hole of said reactant gas, Two pairs of solenoid coils installed on both sides of the reaction container so that it might become in the direction in which it intersects perpendicularly with the electric field between the power source which supplies the power for glow discharge to this electrode for plasma generating, and said two electrodes, and an axis intersects perpendicularly mutually, In the plasma-CVD equipment which forms an amorphous thin film on the substrate supported so that it might come to provide the AC power supply which supplies the power for field generating to these solenoid coils and might intersect perpendicularly with the electric field between said two electrodes The plasma-CVD equipment characterized by a periphery forming the reactant gas installation hole of said electrode for plasma generating so that the discharge quantity of said reactant gas may increase is offered.

[0015]

[Function] Since this invention was made into the above means, reactant gas is introduced in the reaction container of plasma-CVD equipment, the power for glow discharge joins the electrode for plasma generating, and the glow discharge plasma occurs between earth electrodes. Here, if power is supplied to two pairs of solenoid coils from AC power supply, it will be impressed by the glow discharge plasma generated while rotating with a fixed angular velocity in the direction in which the generated field intersects perpendicularly to the electric field between two electrodes, consequently the plasma will be swung in all the directions in the inside of a field parallel to two electrodes, i.e., a field parallel to a substrate. On the other hand, since reactant gas is formed so that the reactant gas installation hole of discharge quantity prepared in the electrode for plasma generating may increase in number along with ****** in a

periphery from a center section, it comes to be mostly distributed in a periphery with few consistencies, and it can be introduced so that it may become homogeneity distribution efficiently to inter-electrode. Therefore, an inter-electrode plasma consistency is equalized still in time than the equalization on the turning effort of the synthetic field generated from two pairs of solenoid coils, and spatially. Consequently, the thin film formed by the substrate front face comes to have uniform thickness distribution in the whole substrate, and fits manufacture of the amorphous thin film of a large area.

[0016]

[Example] Hereafter, this invention is concretely explained based on the example shown in a drawing. The top view of the electrode for plasma generating in the example of drawing 1 and drawing 3 of the sectional view and drawing 2 which show the configuration of the plasma-CVD equipment which drawing 1 requires for one example of this invention are the side elevation. The part used as the description of this invention is a part of the reactant gas installation hole of the sign 101 prepared in the electrode for plasma generating and this electrode of a sign 30, and since other configurations are the same as the conventional CVD system shown in drawing 9 , they quote and explain the same sign.

[0017] In the reaction container 1, the electrode 30 and earth electrode 3 for generating the glow discharge plasma are arranged in parallel mutually. This electrode 30 for plasma generating has many reactant gas installation holes 101, as shown in the top view of drawing 2 , and the side elevation of drawing 3 , and if it centers on one reactant gas installation hole 101 as shown in the reactant gas installation hole plot plan of drawing 4 since the adjoining reactant gas installation hole 101 is arranged at fixed spacing, other reactant gas installation holes 101 will be arranged in the shape of [which is shown with a sign 40] a forward hexagon. Moreover, the reactant gas installation hole 101 enlarges the diameter of the reactant gas installation hole 101 gradually as it approaches a periphery from the center section of the electrode 30 for plasma generating.

[0018] The diameter of the reactant gas installation hole 101 is set up so that it may become shorter than the mean free path of the electron in the pressure range of 0.05 - 0.5Torr. Specifically, 3mm or less of a diameter is desirable. Since it becomes longer than the mean free path of the electron under the pressure of 0.05 - 0.5Torr, the plasma will occur in the reactant gas installation hole 101, and the reason will cause the fall of the membrane formation rate of the thin film formed on the substrate by the fall of the above-mentioned inter-electrode plasma consistency, and the heterogeneity of distribution, and the ununiformity of thickness distribution, if the diameter of 3mm is exceeded.

[0019] Drawing 5 is the detailed side elevation of the electrode 30 neighborhood for plasma generating, and the electrode 30 whole for plasma generating which has many reactant gas installation holes 101 with which diameters differ is covered with the ground shielding 19. The ground shielding 19 is connected to the ground 9 through the reaction container 1 and the 2nd high frequency cable 8. The gap of the ground shielding 19 and the electrode 30 for plasma generating was made shorter than an electronic mean free path like the diameter of the plasma installation hole 101, in order to control that the plasma occurs in the gap. The seal of the gap of the ground shielding 19 and the electrode 30 for plasma generating is carried out to the ultra-high vacuum, using O ring 21 of the non-conductivity quality of the material for some. The power of the frequency of 13.56MHZ(s) is supplied to the electrode 30 for plasma generating through an impedance matching box 5 and the 1st high frequency cable 6, for example as a desirable frequency from RF generator 4.

[0020] In addition, although the electrode 30 for plasma generating is circular in this example, ground shielding which accompanies the configuration and this may not be circular, or a square shape is sufficient, and if it considers so that the plasma installation hole 101 may be arranged by the periphery at homogeneity, it will not be limited circularly.

[0021] A mono silane is introduced into the gap of the ground shielding 19 and the electrode 30 for plasma generating through the reactant gas installation tubing 11 from the bomb which reactant gas G does not illustrate, and a flowmeter. The reactant gas between the ground shielding 19 and the electrode 30 for plasma generating passes along many reactant gas installation holes 101 with which the diameters of the electrode 30 for plasma generating differ, and is supplied between an earth electrode 3 and the electrode 30 for plasma generating. It returns to drawing 1 R> 1, and the reactant gas in the reaction container 1 is exhausted like illustration with Sign E by the vacuum pump which does not pass along and illustrate an exhaust pipe 12. A substrate 13 is supported by the substrate holder which is not illustrated on the earth electrode 3 parallel to the electrode 30 for plasma generating which has the reactant gas installation hole 101.

[0022] Around the reaction container 1, the solenoid coils 14a and 14b of finite length with the 1st - the 4th thickness, and 15a and 15b are arranged. Drawing 6 is the top view of electrode disposition, and it is arranged so that it may agree in the direction, i.e., X shaft orientations, where the 1st and 2nd solenoid coils 14a and 14b cross a pair perpendicularly, and coincidence and nothing and each axis cross a pair at right angles mutually also in nothing and the 3rd and 4th solenoid coils 15a and 15b, and Y shaft orientations.

[0023] The power of a sinusoidal form is supplied to the 1st and 2nd solenoid coils 14a and 14b through the 1st power amplifier 17 from one output terminal of the phase adjustable 2 output oscillator 16. The power of a sinusoidal form is supplied through the 2nd power amplifier 18 from the output terminal of another side of the phase adjustable 2 output oscillator 16 also like the 3rd and 4th solenoid coils 15a and 15b.

[0024] The above-mentioned phase adjustable 2 output oscillator 16 is what sets each relative topology as arbitration and outputs two sinusoidal signals. the field which the 1st and 2nd solenoid coils 14a and 14b generate -- the direction of an axis (X shaft orientations) -- about 1 -- the field which is intensity distribution [like] and the 3rd and 4th solenoid coils 15a and 15b generate -- the same -- the direction of an axis (Y shaft orientations) -- about 1 -- they are intensity distribution [like].

[0025] Next, the case where an amorphous silicon thin film is manufactured using the above-mentioned equipment is made into an example, and the operation is explained. After driving the vacuum pump of an

illustration abbreviation of the inside of the reaction container 1 and fully exhausting (for example, 1x1/107 Torr), a mono silane is supplied through the reactant gas installation tubing 11 by 50-100 cc flow rate for /, and the pressure in the reaction container 1 is maintained at 0.05 - 0.5Torr. Then, if power is supplied to the electrode 30 for plasma generating through an impedance matching box 5, the current installation terminal 7, etc. from RF generator 4, the glow discharge plasma of a mono silane will occur between two electrodes.
[0026] On the other hand, sinusoidal power with a frequency of 10Hz which shifted 90 degrees of phases is impressed to the 3rd and 4th solenoid coils 15a and 15b for two outputs from the phase adjustable 2 output oscillator 16 through the 1st and 2nd power amplifier 17 and 18 at the 1st and 2nd solenoid coil 14a and 14b list, respectively. At this time, the synthetic field of the field by the 1st and 2nd solenoid coils 14a and 14b and the field by the 3rd and 4th solenoid coils 15a and 15b occurs. This synthetic field is impressed to the above-mentioned glow discharge plasma, rotating by fixed angular-velocity 20pi (radian per second) in the rectangular direction to the electric field between the plasma electrode pattern 30 and an earth electrode 3. Consequently, the glow discharge plasma receives the force (E-B drift) rotated with a fixed angular velocity. Therefore, the plasma between the plasma electrode pattern 30 and an earth electrode 3 is swung in all the directions in the inside of a field parallel to a substrate 13. In addition, the synthetic magnetic field strength in this case is good at about 20-100 gauss.
[0027] It depends for thickness distribution of an amorphous silicon thin film and a membrane formation rate on the area of an electrode, an electrode spacing, the flow rate of reactant gas, a pressure, the power supplied to inter-electrode, the synthetic magnetic field strength impressed to the glow discharge plasma. Then, the amorphous silicon thin film was produced on the conditions shown below.
[0028] 500mmx500mm**7059 alkali free glass was used as a substrate 13, using a disc electrode with a diameter of 800mm as an electrode. As reactant gas, mono-silane gas was supplied by 50 cc flow rate for /100%, and it was set as 0.1Torr(s) as a pressure in the reaction container 1. The high-frequency power of 50W was impressed to the plasma electrode pattern 30 from RF generator 4. The synthetic magnetic field strength impressed with solenoid coils 14a, 14b, 15a, and 15b was set as 0, 20, 40, and 60 or 80,100 gauss.
[0029] Drawing 7 and drawing 8 are the graphs in comparison with what was obtained by the conventional approach based on the data which manufactured the thin film on such conditions. Drawing 7 is what set the synthetic field as 100 gauss, shows the relation between the distance from a substrate core, and thickness distribution, and is understood that thickness distribution is uniform distribution from the conventional distribution 60 which the distribution 50 by this invention as which it entered with a circle [of the (a) Fig. / white] displayed by the black dot of the (b) Fig. covering a large distance (area).
[0030] Drawing 8 is what showed the relation between magnetic field strength and the membrane formation rate of the obtained amorphous silicon thin film, and it turns out that a membrane formation rate improves rather than that from which the rate 51 of this invention displayed with a circle [white] was obtained at the rate of [61] the former shown by the black dot. Moreover, the effectiveness of improving a membrane formation rate much more from before is large as magnetic field strength becomes large.
[0031] In addition, although it explained in the above-mentioned example as arrangement which enlarged the diameter gradually as the reactant gas installation hole 101 of the electrode 30 for plasma generating was separated from the core to the periphery When the pitch of a hole is made dense and arranged as the diameter of a hole is separated from a core to a periphery as fixed as well as the former, like Even if it makes it the discharge quantity of gas increase as a means to carry out or to adjust discharge quantity is established and it becomes an electrode periphery, the same effectiveness as the above-mentioned example is acquired.
[0032]
[Effect of the Invention] As mentioned above, since it formed so that it became the periphery of an electrode about the reactant gas installation hole of the electrode for plasma generating according to [as explained concretely] the plasma-CVD equipment of this invention and the discharge quantity of reactant gas might increase, reactant gas can be efficiently introduced to inter-electrode, therefore distribution of reactant gas can be made into homogeneity by the center section and the periphery. Therefore, in case a thin film is manufactured to a substrate by the glow discharge plasma, a large area can also form the amorphous thin film of uniform thickness by the substrate center section and the periphery at high speed. According to this effectiveness, industrial worth of the manufacture fields [, such as an amorphous-silicon solar cell which has a large area, a thin film transistor for liquid crystal displays, and a photoelectron device,] becomes remarkably large.

[Translation done.]

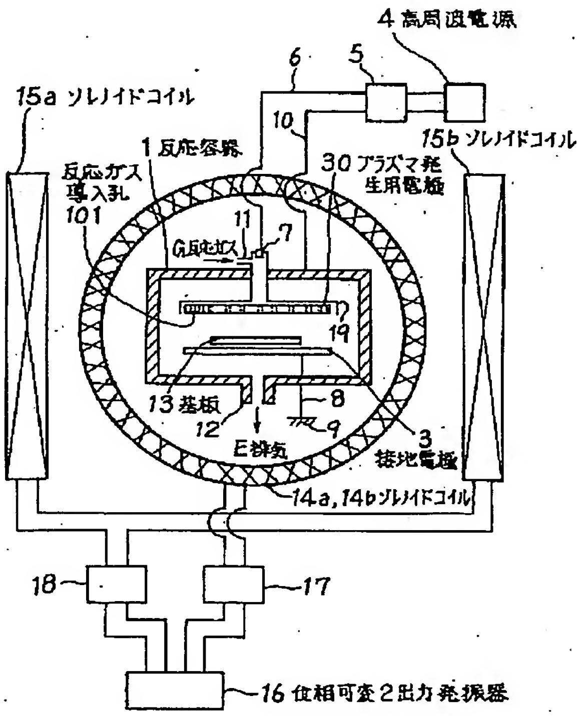
DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is the sectional view showing the configuration of the plasma-CVD equipment concerning one example of this invention.
[Drawing 2] It is the top view of the electrode for plasma generating in the example in drawing 1 .
[Drawing 3] It is the side elevation of the electrode for plasma generating of drawing 1 .
[Drawing 4] It is the plot plan showing the physical relationship of the reactant gas installation hole of the electrode for plasma generating in drawing 2 .
[Drawing 5] It is the detail drawing of the electrode neighborhood for plasma generating in drawing 1 .
[Drawing 6] It is the plot plan of a common reaction container and a solenoid coil in plasma-CVD equipment.
[Drawing 7] What (a) depends on this invention in the graph of the thickness distribution which shows the effectiveness of this invention, and (b) are distribution by the conventional approach.
[Drawing 8] It is the graph which shows the relation between the magnetic field strength which shows the effectiveness of this invention, and a membrane formation rate.
[Drawing 9] It is the sectional view showing the configuration of conventional plasma-CVD equipment.
[Drawing 10] It is the top view of the conventional electrode for plasma generating in drawing 9 .
[Drawing 11] It is the side elevation of the conventional electrode for plasma generating in drawing 10 .
[Description of Notations]
1 Reaction Container
3 Earth Electrode
4 RF Generator
13 Substrate
14a Solenoid coil
14b Solenoid coil
15a Solenoid coil
15b Solenoid coil
16 Phase Adjustable 2 Output Oscillator
30 Electrode for Plasma Generating
101 Reactant Gas Installation Hole

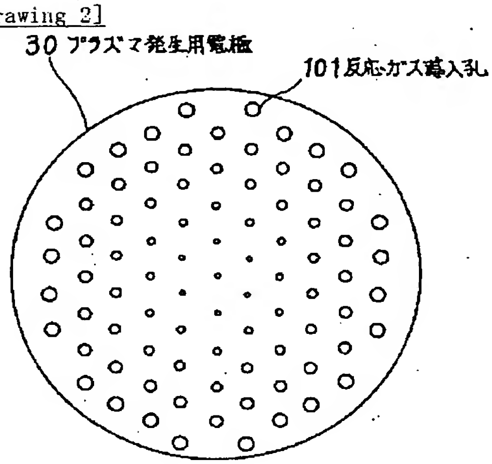
[Translation done.]

DRAWINGS

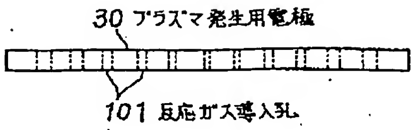
[Drawing 1]



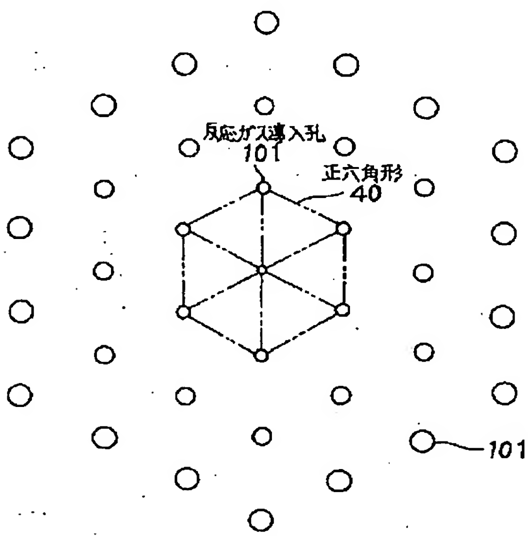
[Drawing 2]



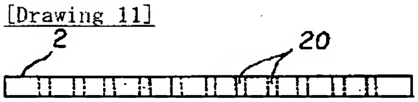
[Drawing 3]



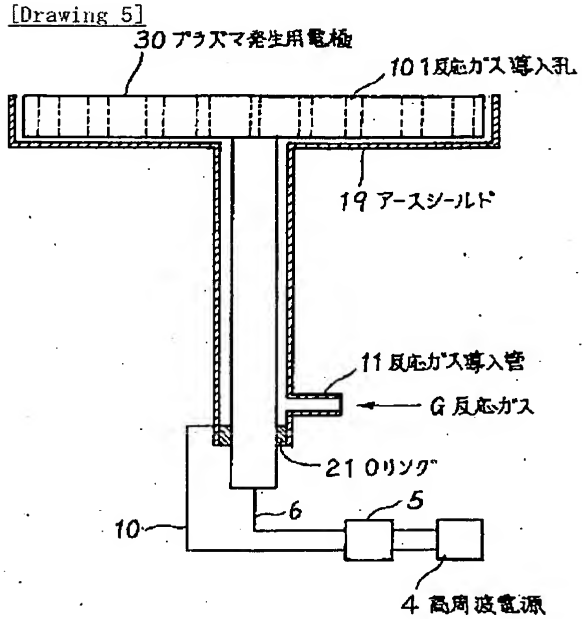
[Drawing 4]



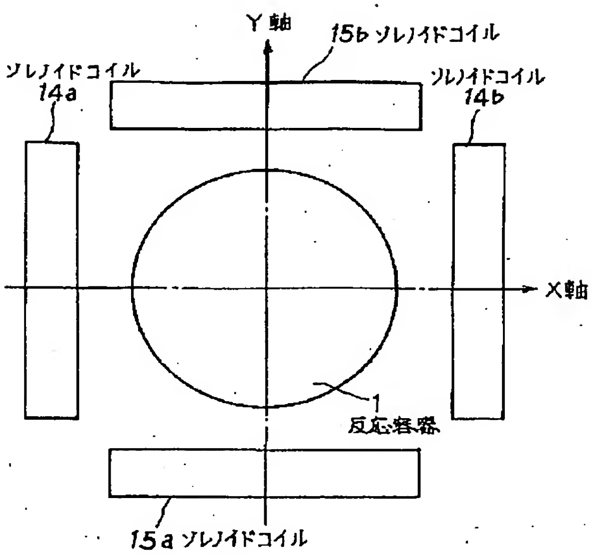
[Drawing 11]



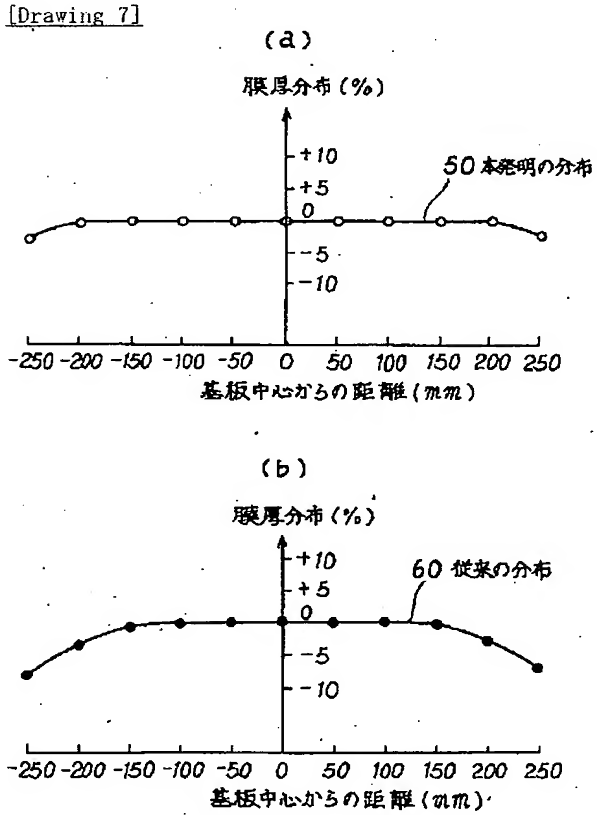
[Drawing 5]



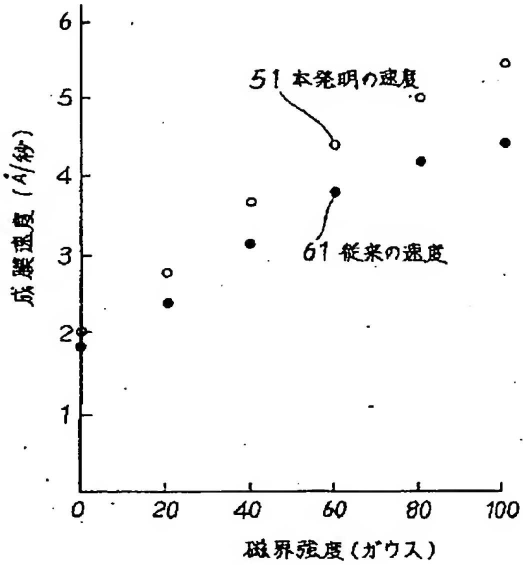
[Drawing 6]



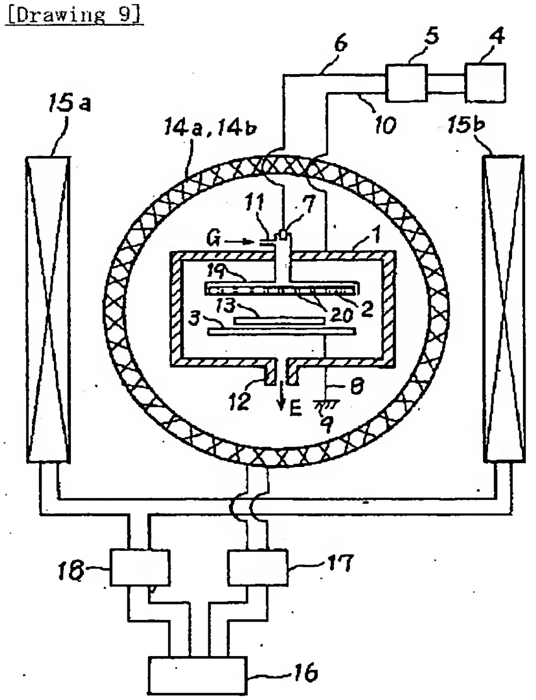
[Drawing 7]



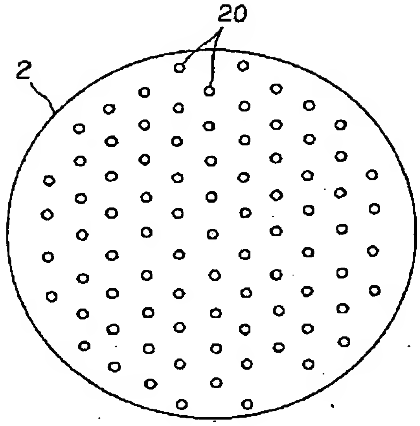
[Drawing 8]



[Drawing 9]



[Drawing 10]



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